

FIG. 1A

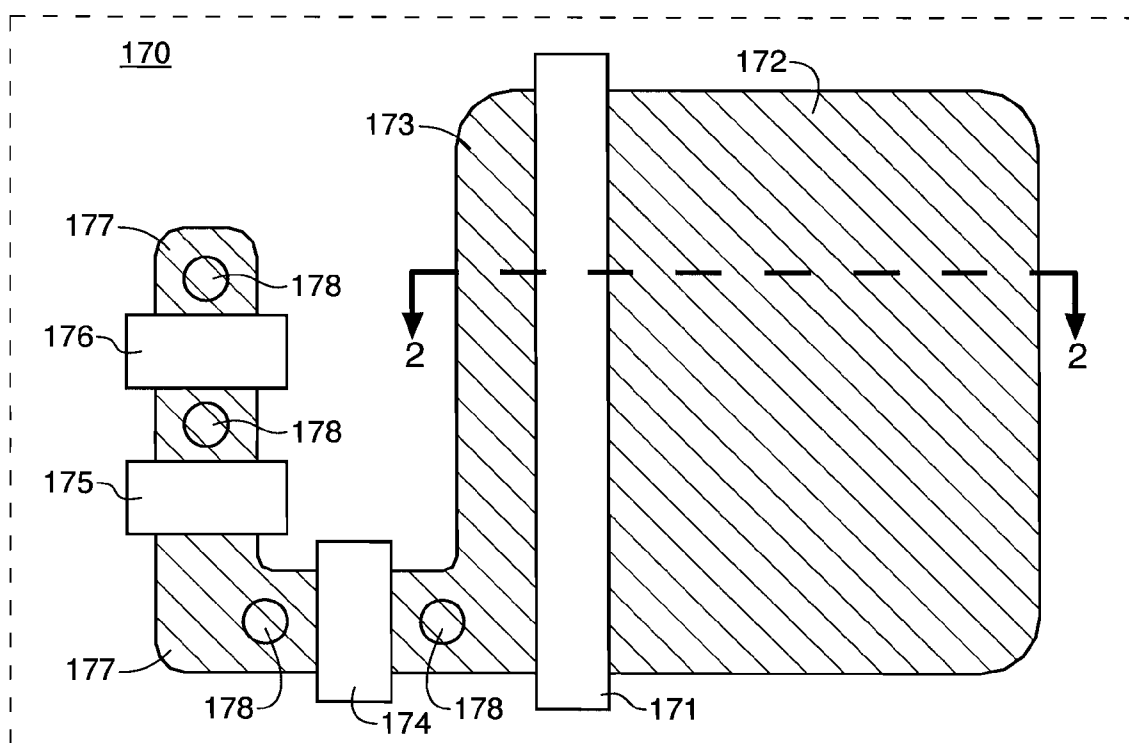


FIG. 1B

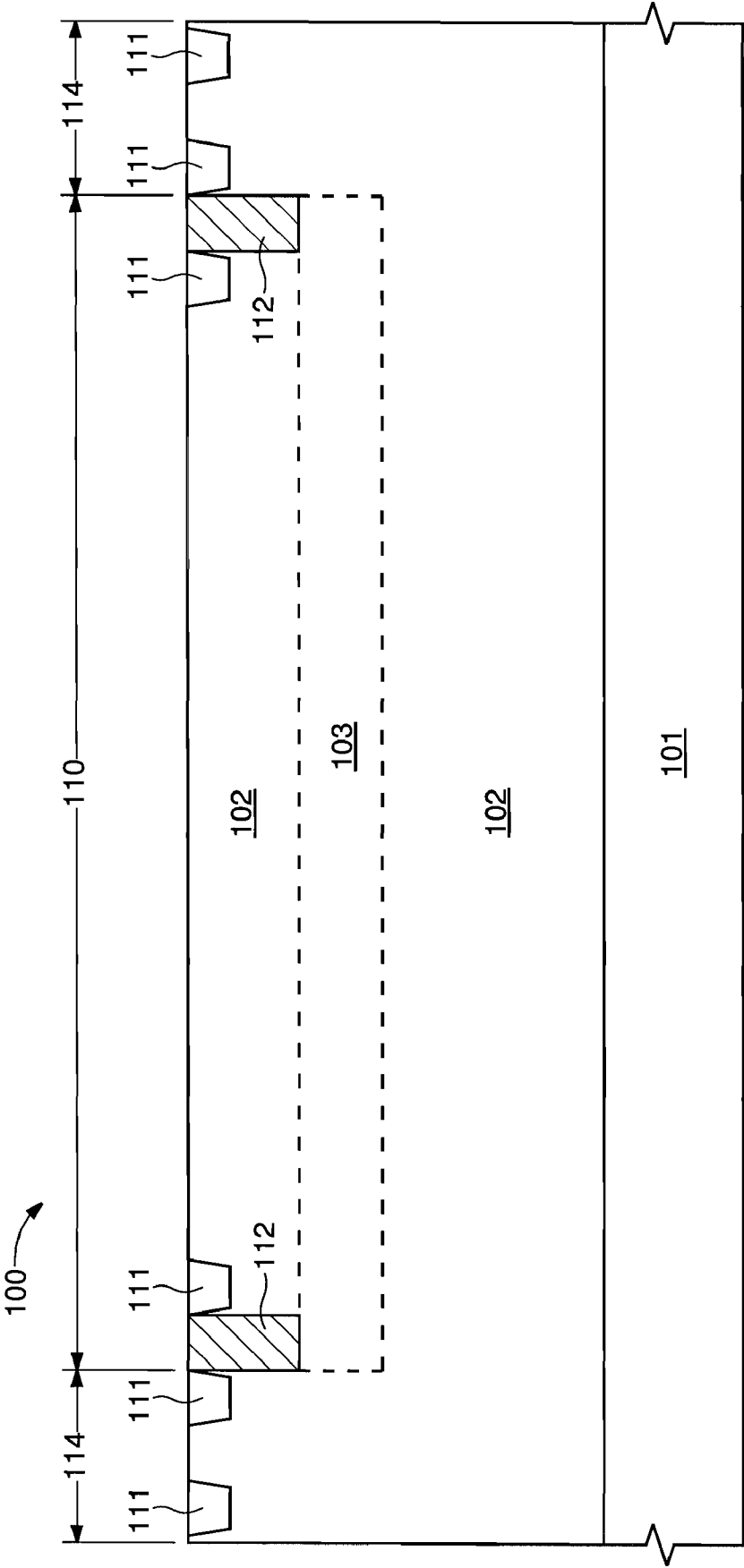


FIG. 1C

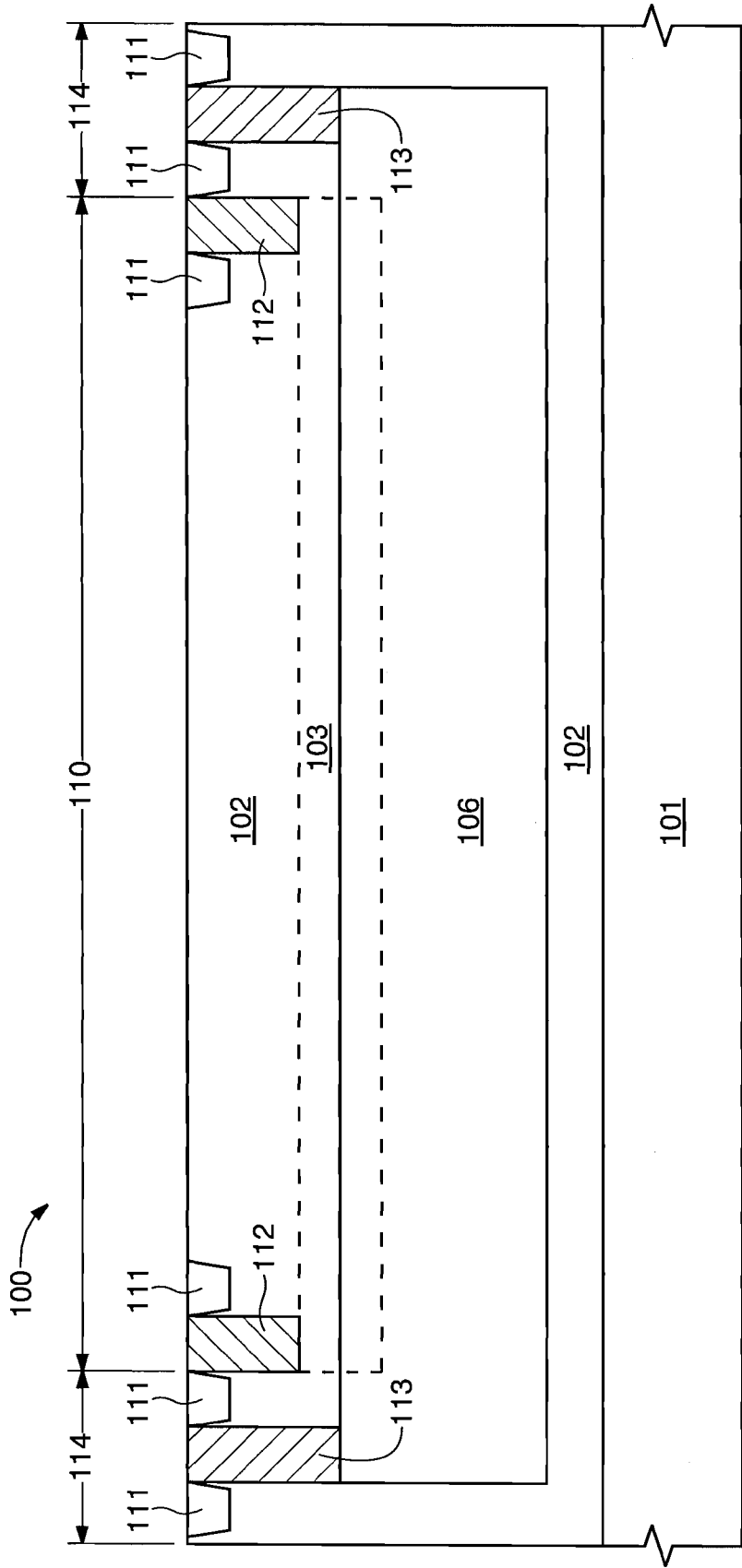


FIG. 1D

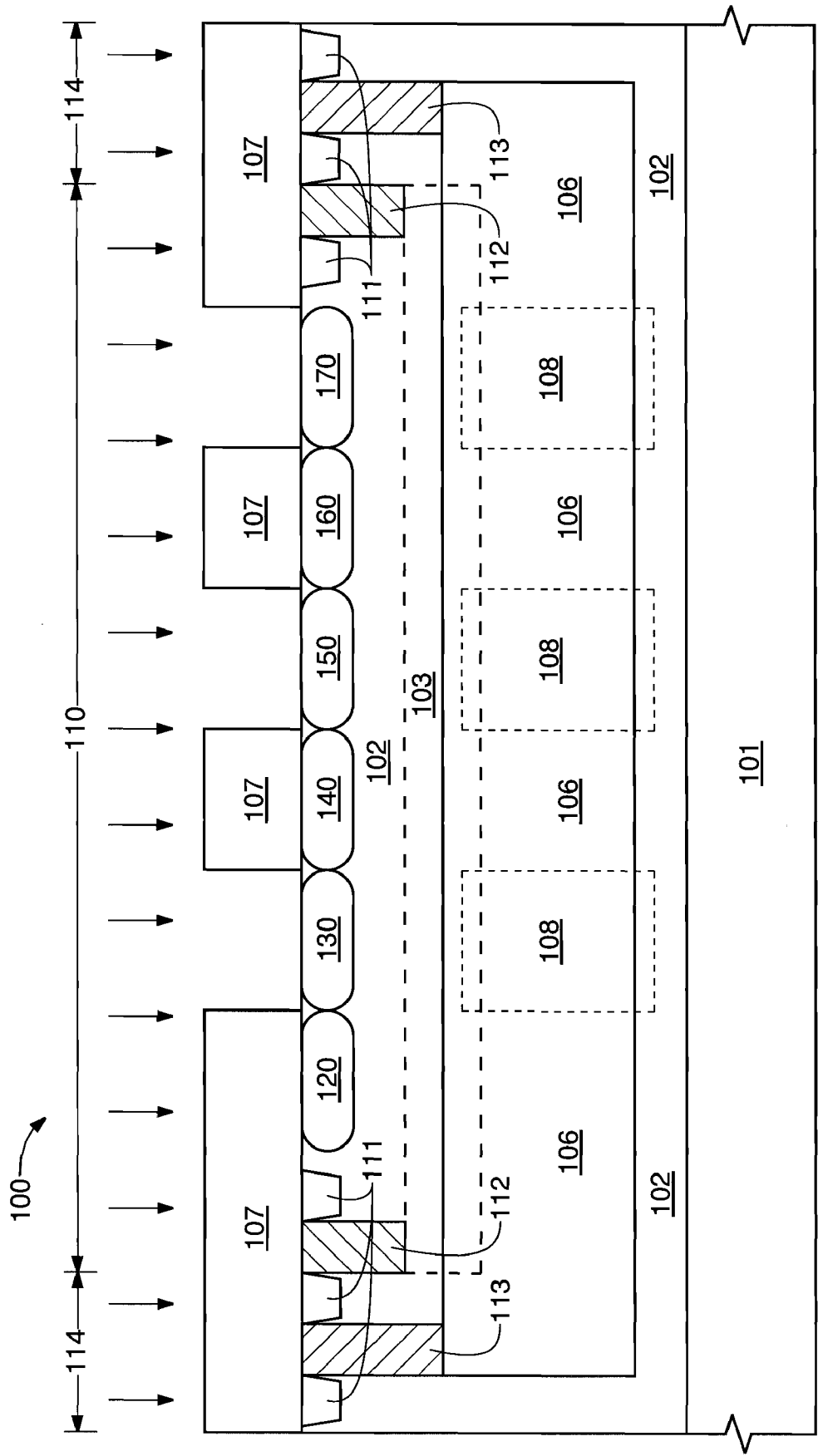


FIG. 1E

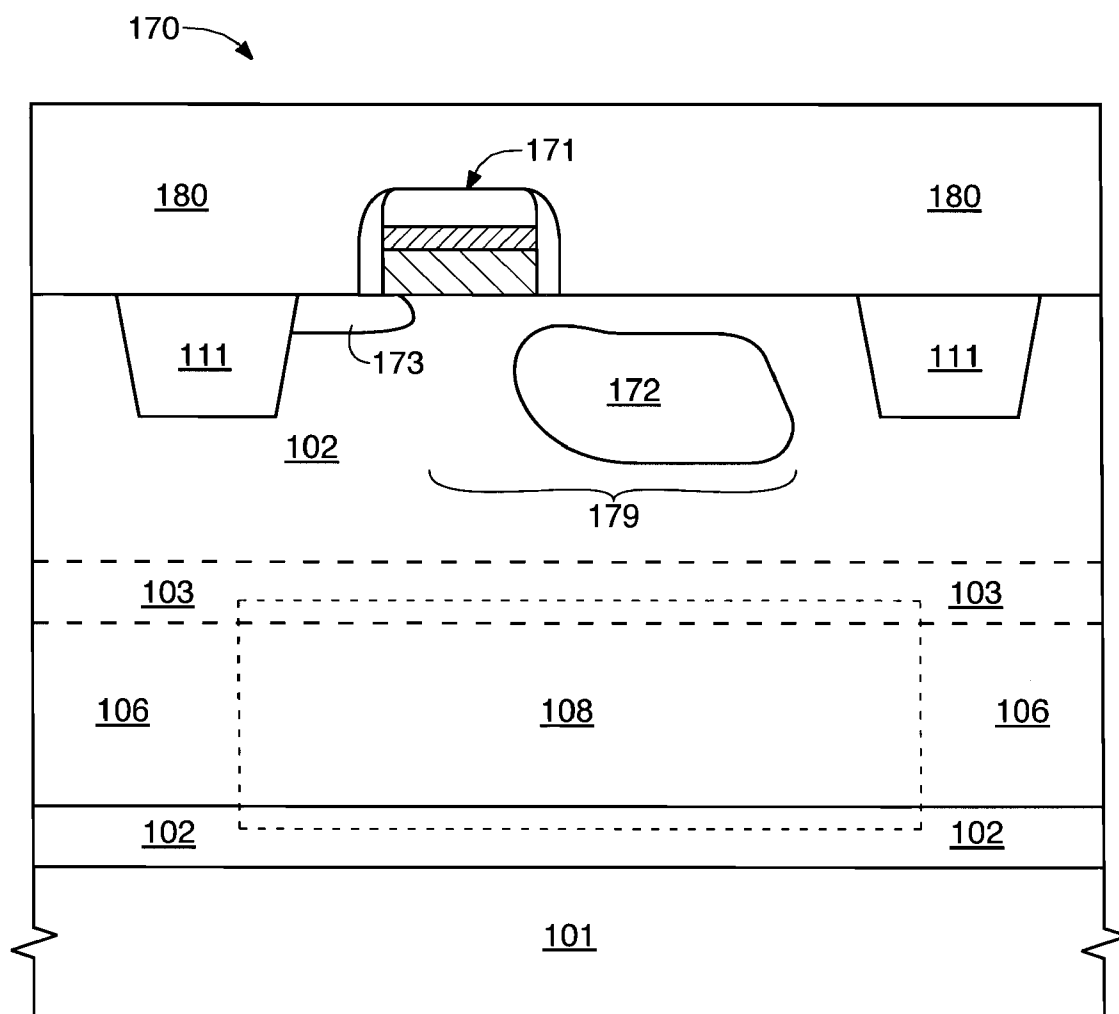


FIG. 1F

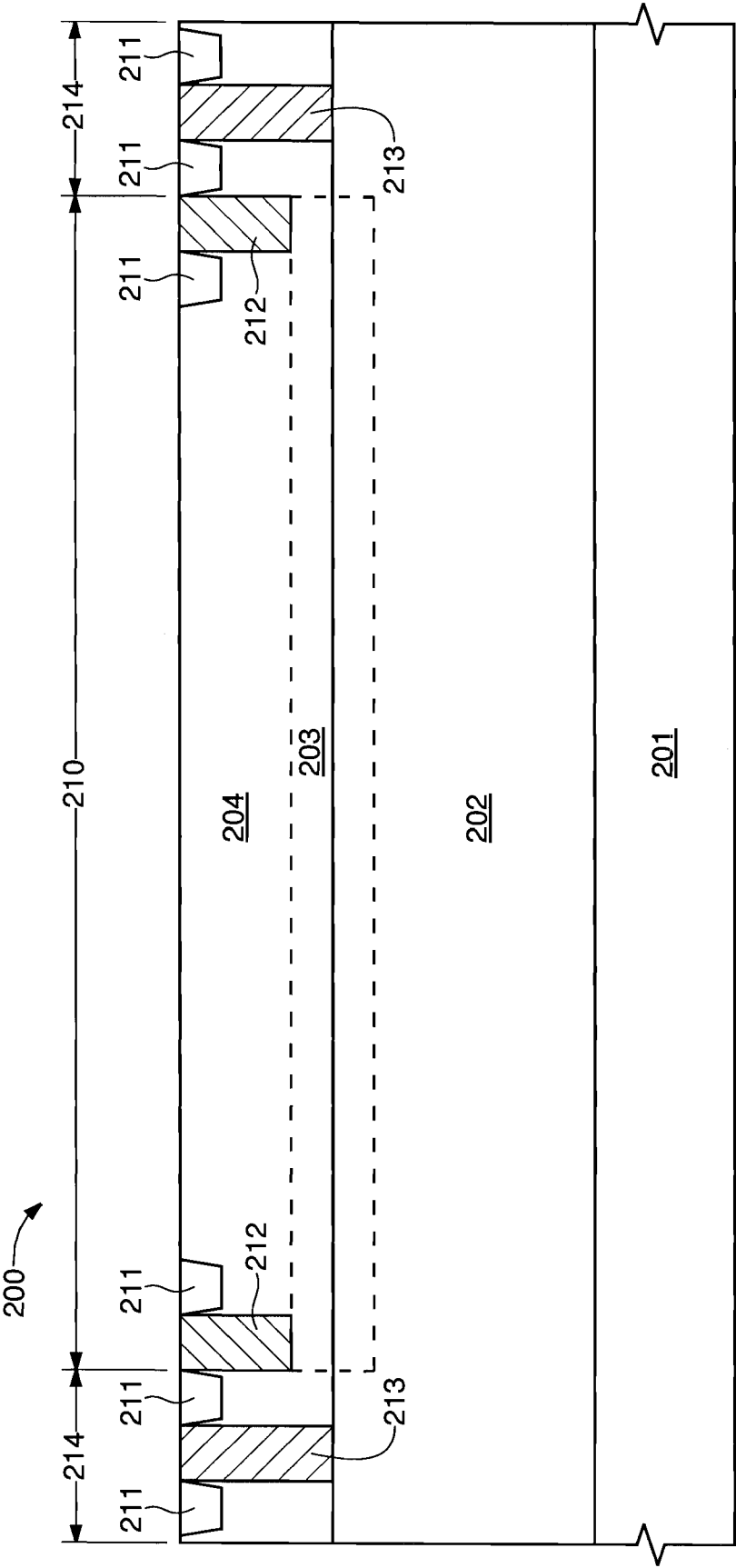
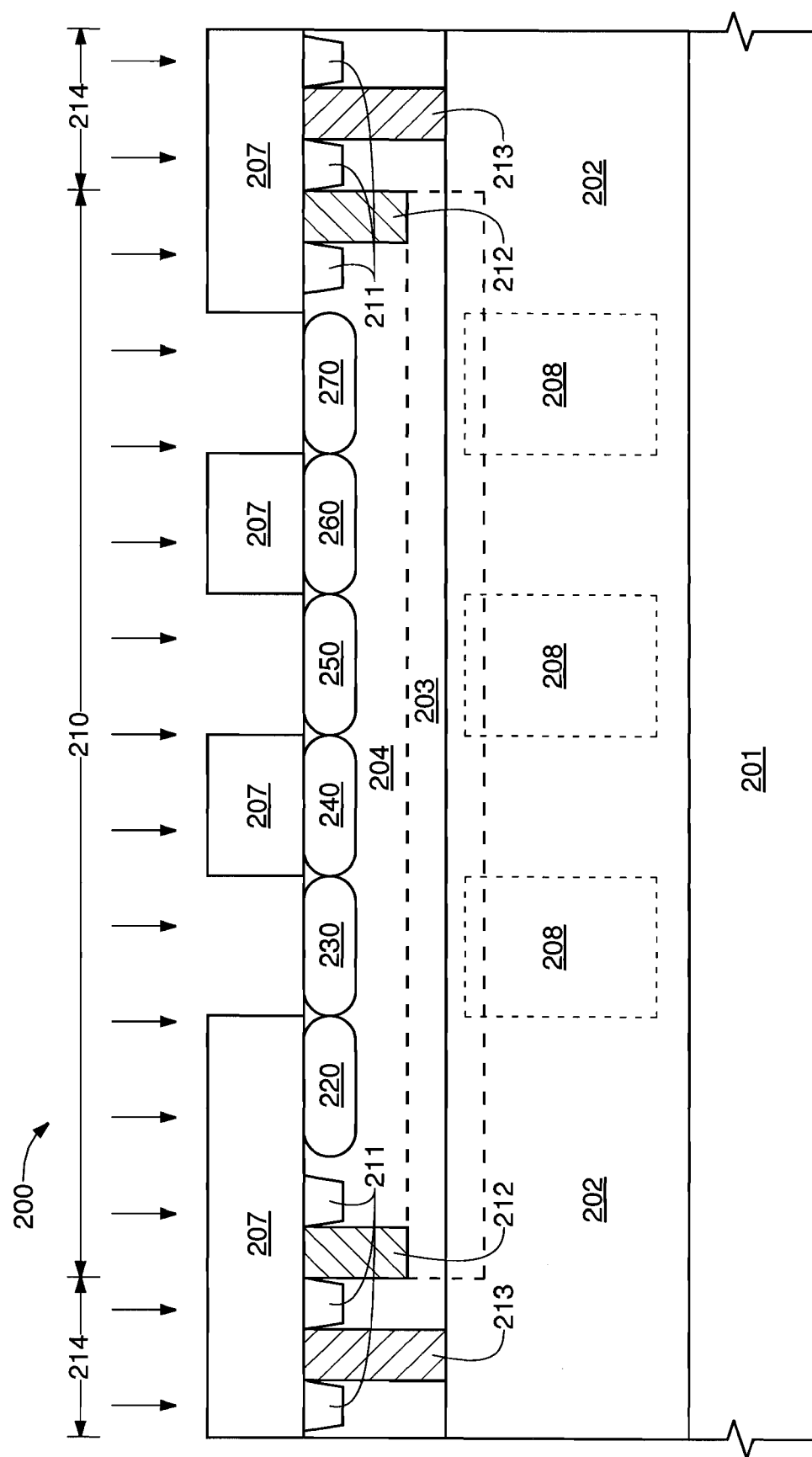


FIG. 2C



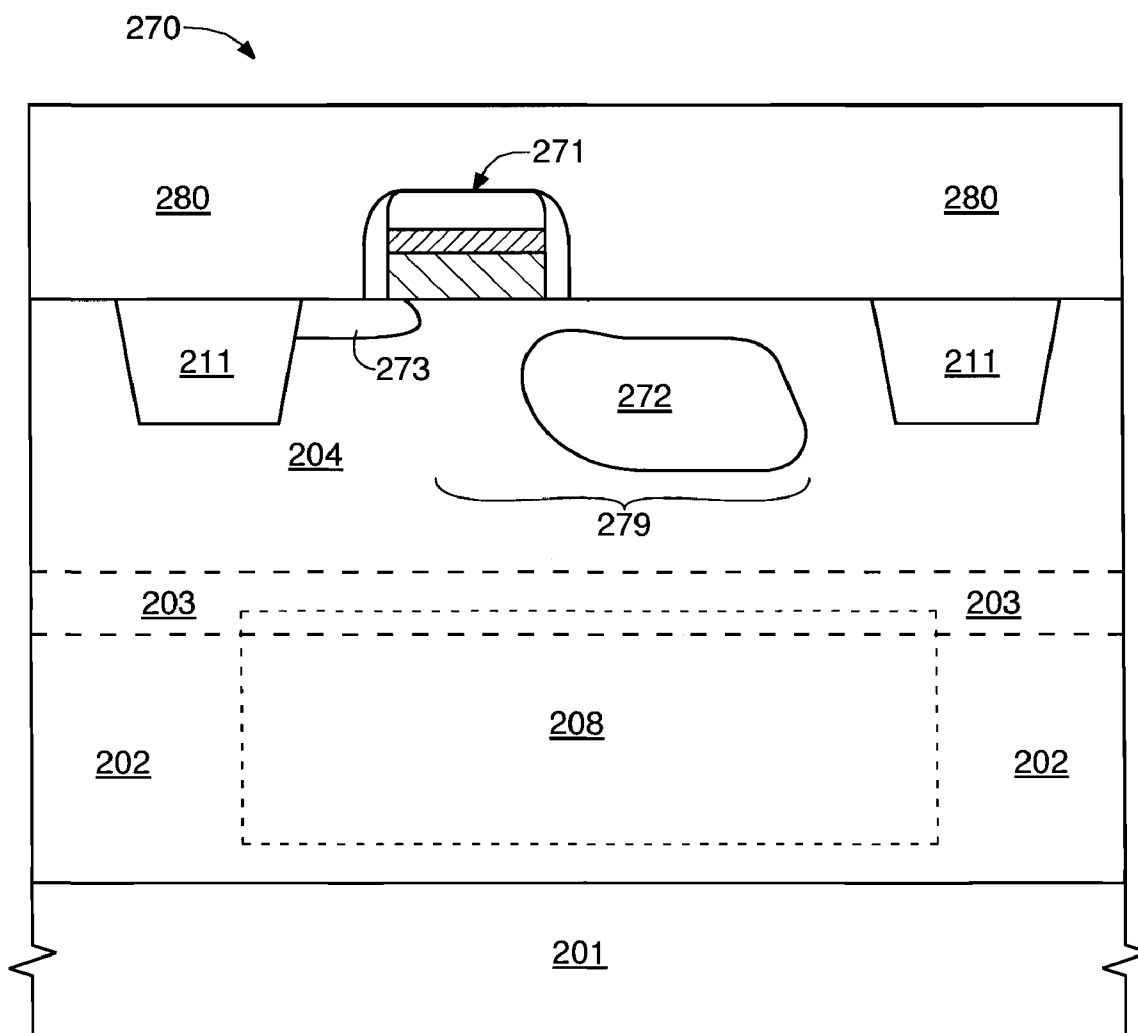


FIG. 2E

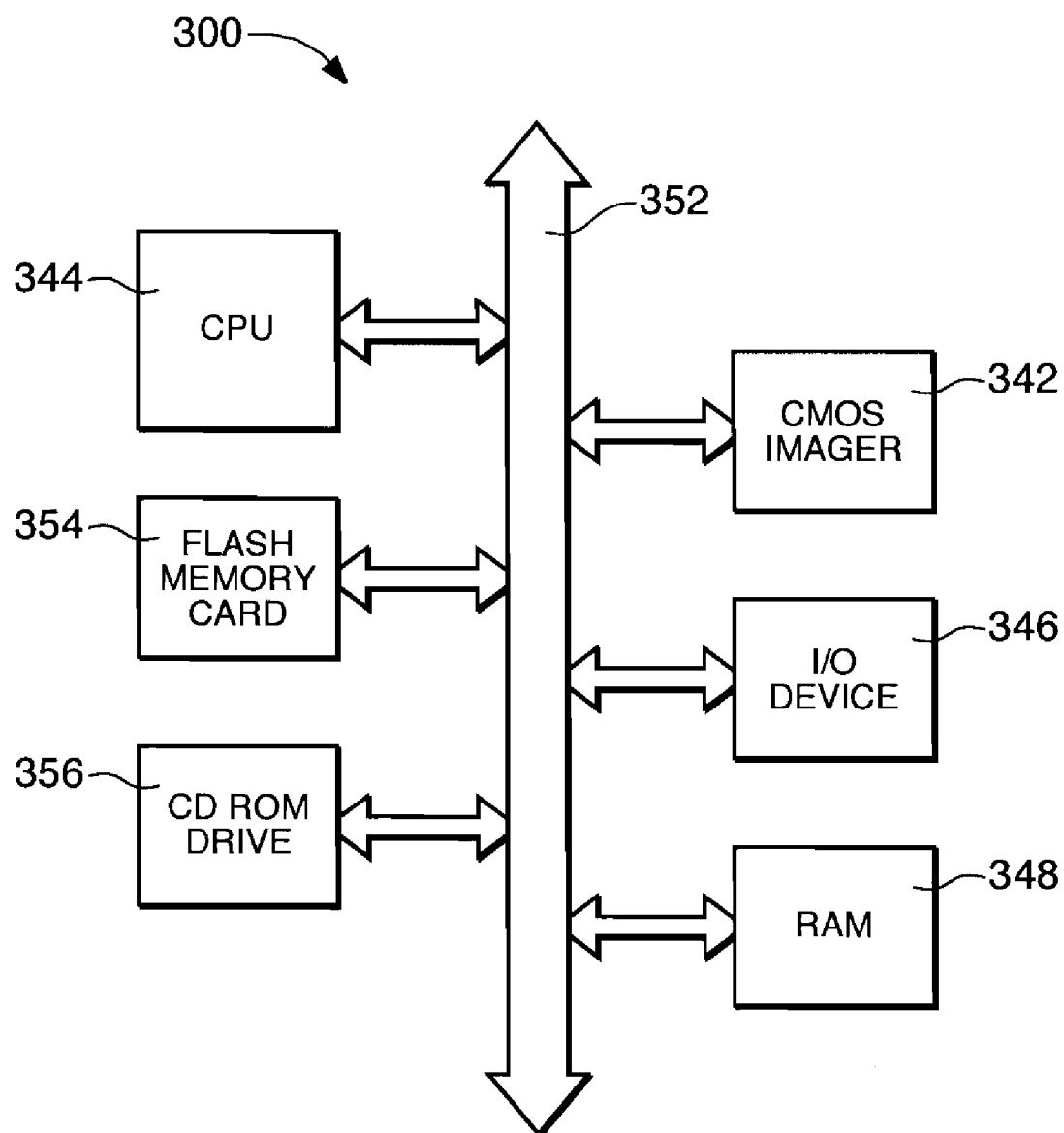


FIG. 3

METHODS, STRUCTURES AND SYTEMS FOR AN IMAGE SENSOR DEVICE FOR IMPROVING QUANTUM EFFICIENCY OF RED PIXELS

TECHNICAL FIELD

[0001] This invention relates to semiconductor imaging devices and fabrication methods thereof and more specifically to imaging arrays and methods for forming same.

BACKGROUND

[0002] In general, a Complimentary Metal Oxide Semiconductor (CMOS) image sensor circuit includes a focal plane array of pixels, each one of the pixels includes a photo-conversion device, e.g., a photogate, photoconductor, or photodiode having an associated charge accumulation region within a substrate for accumulating photo-generated charge. Each pixel may include a transistor for transferring charge from the charge accumulation region to a diffusion node and a transistor for resetting the diffusion node to a predetermined charge level prior to charge transference. The pixel may also include a source follower transistor for receiving and amplifying charge from the diffusion node and an access transistor for controlling the readout of the pixel contents from the source follower transistor. In some arrangements, the transfer transistor is omitted and the charge accumulation region is coupled with the diffusion node.

[0003] In a CMOS image sensor, the active elements of a pixel perform the necessary functions of: (1) photon to charge conversion; (2) accumulation of image charge; (3) transfer of charge to the diffusion node accompanied by charge amplification (where a transfer transistor is used); (4) resetting the diffusion node to a known state before the transfer of charge to it; (5) selection of a pixel for readout; and (6) output and amplification of a reset signal and a signal representing pixel charge from the diffusion node. The charge at the floating diffusion node is typically converted to a pixel output voltage by the source follower output transistor.

[0004] However the CMOS image sensor is susceptible to the generation of dark current that is generally attributed to leakage in the charge collection region of the pinned photodiode, which is strongly dependent on the doping implantation conditions of the CMOS image sensor. In addition, defects and trap sites inside or near the photodiode depletion region strongly influence the magnitude of dark current generated. In summary, dark current is a result of current generated from trap sites inside or near the photodiode depletion region, surface leakage at silicon/surface interface; band-to-band tunneling induced carrier generation as a result of high fields in the depletion region; junction leakage coming from the lateral sidewall of the photodiode; and leakage from isolation corners, for example, stress induced and trap assisted tunneling.

[0005] U.S. Patent Application Publication US 2005/0133825 A1, the contents of which are incorporated herein by reference as if set forth in its entirety, discusses methods and structures for reducing dark current in an image sensor by preventing unwanted electrons from being collected in the photosensitive regions of the pixels. In US 2005/0133825 A1, dark current is reduced by providing a deep n-type region having an n-type peripheral sidewall formed in a p-type sub-

strate region underlying a pixel array region to separate the pixel array region from a peripheral circuitry region of the image sensor.

[0006] Dark current is but one of the inherent operational challenges in CMOS image sensors, as another area of focus is maximizing the fill factor as pixel size decreases. A significant portion of the pixel area is dedicated to the support transistors (amplifier, reset, and row select), which are relatively opaque to visible light photons and cannot be utilized for photon detection. The remaining area is utilized as the photosensitive part of the pixel. Because such a small portion of the photodiode is actually capable of absorbing photons to generate charge, the fill factor or aperture of the CMOS image sensor represents only portion of the total photodiode array surface area. Low fill factors can result in a significant loss in sensitivity and a corresponding reduction in signal-to-noise ratio, leading to a limited dynamic range. Fill factor ratios vary from device to device, but in general, they range from 30 to 80 percent of the pixel area in CMOS image sensors.

[0007] Compounding the reduced fill factor problem is the wavelength-dependent nature of photon absorption, a term referred to as the quantum efficiency of CMOS image sensors. Three primary mechanisms operate to hamper photon collection by the photosensitive area: absorption, reflection, and transmission. It is common that a majority of the photodiode area may be shielded by transistors and stacked or interleaved metallic bus lines, which are optically opaque and absorb or reflect a majority of the incident photons colliding with the structures. Optimizing quantum efficiency in these CMOS image sensors is an ongoing endeavor. Furthermore, when n-type substrates are used to reduce cross-talk, red quantum efficiency is reduced as a result of the thin collection depth of the n-tub or n-type substrate.

[0008] Still another area of focus in CMOS image sensors is the desired reduction of floating body effects when n-type substrates (such as an n-tub as disclosed in U.S. Patent Application Publication US 2005/0133825 A1) are implemented under the image sensor pixel's photosensor (e.g. photodiode). Floating body effects occur when the pixel is grounded only at the edge of the array, so the pixels in the center of the array exhibit an unstable behavior. Metal wiring can be added to ground the pixels, but the additional contact can reduce fill factor and the extra metal routing can block light and thus reduce quantum efficiency.

[0009] Therefore, what is needed in the art is an image sensor which exhibits substantial photon collection depth for the red pixels, increases the quantum efficiency, reduces floating body effects, and maintains the fill factor (pixel density).

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1A is a top-down view of a semiconductor assembly comprising a segment of a CMOS image sensor array in accordance with the present disclosure.

[0011] FIG. 1B is a top-down view of a semiconductor assembly comprising a segment of a single CMOS image sensor red pixel in accordance with the present disclosure.

[0012] FIGS. 1C-1E illustrate cross-sectional views of a semiconductor assembly comprising a segment of a CMOS image sensor device during various stages of fabrication in accordance with a first embodiment of the present disclosure.

[0013] FIG. 1F illustrates a cross-sectional view of a semiconductor assembly comprising an individual red pixel of a

CMOS image sensor device in accordance with a first embodiment of the present disclosure.

[0014] FIGS. 2C-2D illustrate cross-sectional views of a semiconductor assembly comprising a segment of a CMOS image sensor device during various stages of fabrication in accordance with a second embodiment of the present disclosure.

[0015] FIG. 2E illustrates a cross-sectional view of a semiconductor assembly comprising an individual red pixel of a CMOS image sensor device in accordance with a second embodiment of the present disclosure.

[0016] FIG. 3 represents a system used to employ any one of the embodiments of the present disclosure.

DETAILED DESCRIPTION

[0017] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration of specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized, and that structural, logical and electrical changes may be made without departing from the spirit and scope of the invention.

[0018] The terms “wafer” and “substrate” are to be understood as including silicon, silicon-on-insulator (SOI), or silicon-on-sapphire (SOS) technology, doped and undoped semiconductors, epitaxial layers of silicon supported by a base semiconductor foundation, and other semiconductor structures. Furthermore, when reference is made to a “wafer” or “substrate” in the following description, previous process steps may have been utilized to form regions or junctions in the base semiconductor structure or foundation. In addition, the semiconductor need not be silicon-based, but could be based on other semiconductors including silicon-germanium, germanium, or gallium-arsenide.

[0019] The term “pixel” refers to a picture element unit cell containing a photosensor and transistors for converting electromagnetic radiation to an electrical signal.

[0020] Preferred embodiments of the present disclosure provide structures and methods to improve quantum efficiency, reduce floating body effects, and add ground contacts for the red pixels while maintaining the fill factor (pixel density) in CMOS image sensors, as described below with reference to FIGS. 1A-1F and FIGS. 2C-2E.

[0021] FIG. 1A illustrates a top view of a CMOS image sensor indicated generally by reference numeral **100**. CMOS image sensor **100** comprises a peripheral substrate region **114** and a pixel array substrate region **110**. Field oxide regions **111** are used to isolate individual pixels as well as to isolate circuits in the peripheral substrate region **114** from the pixel array substrate region **110**. A p-type conductive guard ring **112** surrounds the CMOS image sensor pixel array **115**, which in turn is surrounded by an n-type conductive guard ring **113**. The locations of the individual pixels are denoted by alternating green and red pixel locations **120**, **130**, **140**, **150**, **160** and **170** to assist in the discussion of each embodiment of the present disclosure. Other pixels designated to a particular color, such as blue, are assumed to be part of the pixel array substrate region **110** as well, though not specifically shown. Also, it is to be understood that the pixel array substrate region **110**, depicted in FIG. 1A, is not intended to limit the

size of pixel array **115**, but is to serve as an illustration for practicing the concepts disclosed in the embodiments of the present disclosure.

[0022] FIG. 1B illustrates a typical layout of an individual four-transistor (4T) pixel **170**, as illustrated in FIG. 1A. The CMOS image sensor red pixel **170** generally comprises a transfer gate **171** for transferring photoelectric charges generated in a photodiode region **172** to a floating diffusion region **173** acting as a sensing node, which is in turn electrically connected to the gate **175** of an output source follower transistor. A reset gate **174** is provided for resetting the floating diffusion node (or sensing node) **173** and the photodiode region **172** to a predetermined voltage in order to sense a next signal and a row select gate **176** is provided for outputting a signal from the source follower transistor to an output terminal in response to a pixel row select signal. Contact locations **178** provide for the various metal connections needed for each CMOS image sensor pixel **170** which may or may not be interconnected.

[0023] A CMOS image sensor device in accordance with the first embodiment of the present disclosure is fabricated as depicted in the cross-sectional views of FIG. 1C-1E, that correspond to the generally layout of top down view FIG. 1A and in accordance to the cross-sectional view taken along line 1-1 of FIG. 1A.

[0024] Referring now to FIG. 1C, CMOS image sensor **100** utilizes p-type substrate section **101**. A p-type epitaxial material is grown in the course of epitaxial deposition and then patterned to form p-type epitaxial region **102** on p-type substrate **101** at a thickness of approximately 4 μm and doped to a p-type conductivity using, for example, boron at a concentration of approximately $7\text{E}14$ atoms cm^{-3} .

[0025] Next, field oxide regions **111**, such as by using shallow trench isolation (STI) techniques known to one skilled in the art, are formed in p-type epitaxial region **102**. For example field oxide regions **111** can be formed using a conventional STI process and are typically formed by etching a trench in the substrate via a directional etching process, such as Reactive Ion Etching (RIE), or etching with a preferential anisotropic etchant. The trenches are then filled with an insulating material, for example, silicon dioxide, silicon nitride, ON (oxide-nitride), NO (nitride-oxide), or ONO (oxide-nitride-oxide). The insulating materials may be formed by various chemical vapor deposition (CVD) techniques such as low pressure chemical vapor deposition (LPCVD), high density plasma (HDP) deposition, or any other suitable method for depositing an insulating material within a trench. After the trenches are filled with an insulating material, a planarizing process such as chemical mechanical polishing is used to planarize the structure. Following the formation of field oxide regions **111**, a p-type ground ring **112** is formed inside the pixel array section **110** to form a peripheral p-well wall thereabout and extends to contact the p-type epitaxial region **102** or to an p-type implant region **103**, which is a p-type conductive region formed by an optional p-type implant.

[0026] Referring now to FIG. 1D, a deep n-type region (N-Tub region) **106** is formed into p-type epitaxial region **102** at a depth that sufficiently places the N-Tub region below an upper region of p-type epitaxial region **102**, but in contact with p-type conductive implant region **103** (if present), using for example an n-type implant dose of approximately $5\text{E}12$ atoms cm^{-2} . Next, an n-type sidewall (n-type guard ring) **113** is formed in the peripheral circuit region **114** that extends to

the N-Tub region **106** to form an n-type region isolation structure which separates the pixel array region **110** from the peripheral circuit region **114**.

[0027] Referring now to FIG. 1E, implant mask **107** is patterned so that only the red pixel locations **130**, **150** and **170** are open during a subsequent implant step. Next, a p-type implant is performed to create the p-type ground contacts **108**. The p-type implant must be performed such that the resulting p-type ground contacts **108** are at approximately the same depth, or preferably at a deeper depth than N-Tub region **106**. One method would be to perform the implant using a higher dose than used during the N-Tub region implant so that the p-type implant will over compensate the N-Tub region **106** under the desired red pixel. For example, using a boron dose greater than 5×10^{12} atoms cm^{-3} at an energy level of around 1.4 keV, will sufficiently punch the p-type implant through N-Tub region **106** and into p-type epitaxial region **102**, thus forming the desired grounding contact between an upper region of p-type epitaxial region **102** to a lower region of the p-type epitaxial region **102** through N-Tub region **106** under the red pixel locations. Also the high energy implant will increase the photon collection depth which in turn improve quantum efficiency for the red pixels without increasing the fill factor (pixel density) of CMOS image sensor.

[0028] FIG. 1E also illustrates a CMOS imager sensor structure resulting from the process steps as discussed in accordance with FIGS. 1C-1E. The CMOS image sensor structure of FIG. 1C shows a p-type substrate **101**, on which a p-type epitaxial silicon material **102** is formed. A deep n-type region (N-Tub region) **103** having an n-type peripheral sidewall (N+ guard ring) **113** connecting thereto, such that at least in the pixel array substrate region **110**, the N-Tub region **103** resides above the p-type substrate region **101** and deep within a p-type epitaxial region **102**. The N-Tub region **103** preferably extends under the pixel array substrate region **110** and below the field oxide regions **111** that surround the pixel array substrate region **110**. The N+ guard ring **113** is preferably a contiguous structure that surrounds the pixel array substrate region **110** and extends downwardly and connecting to the N-Tub region **103**. The N+ guard ring **113** being connected to the N-Tub region **103** electrically isolates the pixel array region **110** from the periphery region **114**.

[0029] The pixel array substrate region **110** further includes p-well implants in the form of a peripheral p-well sidewall (p-type ground ring) **112** to frame in the perimeter of the pixel array substrate region **110**. The p-type ground ring **112** can be either contiguous or non-contiguous, in that it may include a plurality of local p-well implants, each of which will make contact to the p-type epitaxial region **102** or to an optional p-type implant region **103**. P-type conductivity grounding regions **108**, make contact between the upper p-type epitaxial region **102** (or the p-type implant region **103**, if present) and the lower p-type epitaxial region under only the red pixel locations.

[0030] FIG. 1F depicts an individual red pixel structure **170** resulting from the process steps of the first embodiment and corresponds to the cross-sectional view along line 2-2 of FIG. 1B. This view represents a red pixel formed by techniques known to one skilled in the art and is meant to show the inclusion of a ground contact structure of the first embodiment. FIG. 1F shows a pinned photodiode **179** having a photosensitive p-n junction region comprising a p-type surface layer in p-type epitaxial region **102** and an n-type photodiode region **172**. An

optional conductive p-type region **103** also lies deep into p-type epitaxial region **102** and a deep N-Tub region **106** is formed in the p-type epitaxial region **102** below the red pixel region. A p-type conductive region **108** forms the desired grounding contact between an upper region of the p-type epitaxial region **102** and a lower region of the p-type epitaxial region **102**. The conductive region **108** (or grounding contact) penetrates completely through N-Tub region **106** and preferably lies directly under the entire red pixel location. P-type grounding contact **108** will provide a low resistance to ground for stray photons from adjoining cells and thus reduce dark non-uniformity effects. The floating diffusion region **173** adjacent to the transfer gate **171**, is also preferably n-type and the red pixel is isolated from neighboring structures by field oxide regions **111** and by overlaying insulating material **180** (typically a planarized translucent or transparent insulating layer, such as SiO_2 , BPSG, PSG, BSG, or SOG).

[0031] A CMOS image sensor device in accordance with a second embodiment of the present disclosure is fabricated as depicted in the cross-sectional views of FIG. 2C-2D, that correspond to the generally layout of top down view FIG. 1A and in accordance to the cross-sectional view taken along line 1-1 of FIG. 1A.

[0032] Referring now to FIG. 2C, CMOS image sensor **200** utilizes an n-type substrate section **201**. An n-type epitaxial material is grown in the course of epitaxial deposition and then patterned to form n-type epitaxial region **202** on n-type substrate **201** at a thickness of approximately $4 \mu\text{m}$ and doped to a n-type conductivity using for example $4 \text{ ohms}^{-\text{cm}}$ at a concentration of approximately 1×10^{15} atoms cm^{-3} .

[0033] Next, field oxide regions **211**, such as by using shallow trench isolation (STI) techniques known to one skilled in the art, are formed in n-type epitaxial region **202**. For example field oxide regions **211** can be formed using a conventional STI process and are typically formed by etching a trench in the substrate via a directional etching process, such as Reactive Ion Etching (RIE), or etching with a preferential anisotropic etchant. The trenches are then filled with an insulating material, for example, silicon dioxide, silicon nitride, ON (oxide-nitride), NO (nitride-oxide), or ONO (oxide-nitride-oxide). The insulating materials may be formed by various chemical vapor deposition (CVD) techniques such as low pressure chemical vapor deposition (LPCVD), high density plasma (HDP) deposition, or any other suitable method for depositing an insulating material within a trench. After the trenches are filled with an insulating material, a planarizing process such as chemical mechanical polishing is used to planarize the structure.

[0034] Following the formation of field oxide regions **211**, a p-type ground ring **212** is formed inside the pixel array section **210** to form a peripheral p-well wall thereabout and extends to contact the p-type implant region **204** or to an p-type implant region **203**, which is a p-type conductive region formed by an optional p-type implant. Next, an n-type sidewall (n-type guard ring) **213** is formed in the peripheral circuit region **214** that extends to the n-type epitaxial region **202** to form an n-type region isolation structure which separates the pixel array region **210** from the peripheral circuit region **214**.

[0035] Referring now to FIG. 2D, implant mask **207** is patterned so that only the red pixel locations **230**, **250** and **270** are open during a subsequent implant step. Next, a p-type implant is performed to create the p-type conductivity extension regions **208**. The p-type implant may be performed such

that the resulting p-type conductivity extension regions **208** are at approximately the same depth as the n-type epitaxial region **202**. One method would be to perform the p-type implant using a high enough dose that will over compensate the n-type epitaxial region **202** under the desired red pixel. For example, using a boron dose greater than 5×10^{12} atoms cm^{-2} at an energy level of around 1.4 keV, will sufficiently punch the p-type implant into the n-type epitaxial region **202**. P-type conductivity extension regions **208** will reduce floating body effects and increase the photon collection depth, which in turn improve quantum efficiency for the red pixels without increasing the fill factor (pixel density) of CMOS image sensor.

[0036] FIG. 2D also illustrates a CMOS imager sensor structure resulting from the process steps as discussed in accordance with FIGS. 2C-1D. FIG. 2D illustrates a CMOS image sensor structure of FIG. 2C depicts an n-type substrate **201**, on which resides N-type epitaxial silicon region **202**. An n-type peripheral sidewall (N+ guard ring) **213** is formed therein that preferably is a contiguous structure that surrounds the pixel array substrate region **210** and extends downwardly and connecting to the N-type epitaxial region **202** to electrically isolate the pixel array region **210** from the peripheral regions **214**.

[0037] The pixel array substrate region **210** further includes p-well implants in the form of a peripheral p-well sidewall (p-type ground ring) **212** formed around the perimeter of the pixel array substrate region **210**. The p-type ground ring **212** can be either contiguous or non-contiguous, in that the p-well wall **212** may include a plurality of local p-well implants, each of which will make contact to an optional p-type implant region **203**. P-type conductivity extension regions **208**, make contact to the upper p-type conductive implant region **204** (or p-type implant region **203**, if present) and extend into the n-type epitaxial region **202** under only the red pixel locations.

[0038] FIG. 2E presents a view of a section of the individual red pixel **270** taken along line 2-2 of FIG. 1B. Referring now to FIG. 2E, a representative red pixel structure **270** is depicted in the cross-sectional view of FIG. 2E in accordance with the general top-down view of FIG. 1B. This view represents a red pixel formed by techniques known to one skilled in the art and is meant to show the inclusion of a conductivity extension region structure of the present disclosure. FIG. 2E shows a pinned photodiode **279** having a photosensitive p-n junction region comprising a p-type surface layer in p-type implant region **204** and an n-type photodiode region **272**. An optional conductive p-type region **203** also lies deep into p-type implant region **204**. A p-type conductive extension region **208** forms the desired conductive path between an upper region of the p-type implant region **204** (or p-type region **203** if present) and into n-type epitaxial region **202**. The p-type conductive extension region **208** penetrates into, if not through, n-type epitaxial region **202** and is located preferably directly under the entire red pixel location. As, previously mentioned, p-type conductivity extension regions **208** will reduce floating body effects and increase the photon collection depth, which in turn improve quantum efficiency for the red pixels without increasing the fill factor (pixel density) of CMOS image sensor. The floating diffusion region **273** adjacent to the transfer gate **271**, is also preferably n-type and the red pixel is isolated from neighboring structures by field oxide regions **211** and by overlaying insulating material **280** (typically a planarized translucent or transparent insulating layer, such as SiO_2 , BPSG, PSG, BSG, or SOG).

[0039] CMOS image sensors of the present disclosure, and described with reference to FIGS. 1C-1F and 2C-2E, may be further processed as known in the art to fabricate a CMOS image sensor device.

[0040] A typical processor system **300**, which includes a CMOS imager **342** having an imaging sensor array formed in the manner described above according to the present disclosure, is illustrated generally in FIG. 3. Processor system **300** is exemplary of a system having digital circuits, which could include the CMOS image sensor **342**. The image sensor **342** provides an image signal produced from the pixels in the pixel array. Without being limiting, such a processor system could include a computer system, camera system, scanner, machine vision, vehicle navigation, video phone, surveillance system, auto focus system, star tracker system, motion detection system, image stabilization system and data compression system for high-definition television, all of which can utilize the invention.

[0041] A processor system **300**, such as a computer system, for example generally comprises a central processing unit (CPU) **344**, for example, a microprocessor that communicates with an input/output (I/O) device **346** over a bus **352**. The CMOS imager **342** also communicates with the system over bus **352**. The computer system **300** also includes random access memory (RAM) **348**, and in the case of a computer system may include peripheral devices such as a flash memory card **354**, or a compact disk (CD) ROM drive **356** which also communicate with CPU **344** over the bus **352**. It may also be desirable to integrate the processor **344**, CMOS image sensor **342** and memory **348** on a single integrated circuit (IC) chip.

[0042] It should be noted that although the present disclosure has been described with specific reference to CMOS image sensors having a photodiode and a floating diffusion region, the invention has broader applicability and may be used in any imaging apparatus. The present disclosure has been described with reference to n-channel devices, for p-channel array devices, however all of the implants can be of a switched type. Similarly, the processes described above are exemplary of many methods that could be used. The above description and drawings illustrate preferred embodiments are not intended to limit the present disclosure to the illustrated embodiments and any modification thereof which comes within the spirit and scope of the following claims.

What is claimed is:

1. A CMOS image sensor structure comprising:

- a p-type substrate underlying a pixel array region and a peripheral region, the p-type substrate having a p-type substrate region and a p-type epitaxial region;
- an n-type region (N-Tub region) having an n-type peripheral sidewall (N+ guard ring) within the p-type epitaxial region, the N-Tub region extending under the pixel array region and below field oxide regions which surround the pixel array region, the pixel array region enclosed by a peripheral p-well sidewall (p-type ground ring), the p-type ground ring extending below the field oxide regions and within and providing an electrical connection to the p-type epitaxial region; and
- p-type conductive implant regions that electrically connect the p-type epitaxial region to the p-type substrate through the N-Tub region at each red pixel location.

2. The method for forming a CMOS image sensor structure of claim 1 further comprising a second p-type conductive implant region separating the N-Tub region from the red pixel locations.

3. The CMOS image sensor structure of claim 1, wherein the N+ guard ring is a contiguous structure that surrounds the pixel array region and extends downwardly to the N-Tub region.

4. The CMOS image sensor structure of claim 1, wherein the N+ guard ring isolates the p-type epitaxial region from the p-type substrate and provides an electrical connection to the N-Tub region.

5. The CMOS image sensor structure of claim 1, wherein the p-type ground ring is either a contiguous or non-contiguous structure that connects the p-type epitaxial to a given potential.

6. A method for forming a CMOS image sensor structure comprising:

forming a p-type epitaxial material on a p-type substrate;
forming field oxide regions in the p-type epitaxial material;
planarizing the field oxide regions and the p-type epitaxial material;

forming a p-type ground ring inside the pixel array section to form a peripheral p-well wall thereabout that extends to contact the p-type epitaxial region;

forming an n-type region (N-Tub region) at a depth that sufficiently places the N-Tub region into the p-type epitaxial region;

forming an n-type sidewall (n-type guard ring) in the peripheral circuit region that extends to the N-Tub region to form an n-type region isolation structure which separates the pixel array region from the peripheral circuit region;

patterning an implant mask that exposes only red pixel locations of a pixel array;

implanting a p-type dopant to create p-type ground contacts at approximately the same depth, or greater depth than N-Tub region, the p-type ground contacts providing electrical connection through the N-Tub region.

7. The method for forming a CMOS image sensor structure of claim 6 further comprising a second p-type conductive implant region separating the N-Tub region from the red pixel locations.

8. The method for forming a CMOS image sensor structure of claim 6, wherein forming the p-type epitaxial layer comprises growing a p-type epitaxial region on the p-type substrate at a thickness of approximately 4 μm and doped to a p-type conductivity with boron at a concentration of approximately $7\text{E}14$ atoms cm^{-3} .

9. The method for forming a CMOS image sensor structure of claim 6, wherein forming field oxide regions comprises shallow trench isolation (STI) techniques.

10. The method for forming a CMOS image sensor structure of claim 6, wherein field oxide regions comprises an insulating material selected from the group consisting of silicon dioxide, silicon nitride, ON (oxide-nitride), NO (nitride-oxide), or ONO (oxide-nitride-oxide).

11. The method for forming a CMOS image sensor structure of claim 6, wherein planarizing the field oxide regions and the p-type epitaxial material comprises chemical mechanical polishing.

12. The method for forming a CMOS image sensor structure of claim 6, wherein forming a deep n-type region (N-Tub

region) comprises an n-type implant dopant dose of approximately $5\text{E}12$ atoms cm^{-3} at an energy level of around 1.4 keV.

13. The method for forming a CMOS image sensor structure of claim 6, wherein implanting a p-type dopant comprises performing a p-type implant step using a higher dose than an implant dose used during the N-Tub region implant.

14. The method for forming a CMOS image sensor structure of claim 6, wherein the p-type implant step uses a boron dose greater than $5\text{E}12$ atoms cm^{-3} at an energy level of around 1.4 keV.

15. A CMOS image sensor structure comprising:

at least one red pixel structure having a n-type photodiode region residing within a p-type epitaxial region;

an N-Tub region residing in the p-type epitaxial region below each red pixel location; and

a p-type conductive implant region extending through the N-Tub region and connecting the p-type epitaxial region bordering a first surface of the N-Tub region to the p-type epitaxial region bordering a second surface the N-Tub region.

16. The CMOS image sensor structure of claim 15 further comprising a second p-type conductive implant region separating the N-Tub region from the red pixel structure.

17. The CMOS image sensor structure of claim 15 further comprising a pinned photodiode having a photosensitive p-n junction region comprising a p-type surface layer and an n-type photodiode region.

18. The CMOS image sensor structure of claim 15 further comprising:

a floating diffusion region adjacent to an n-type conductive transfer gate;

each red pixel structure isolated from neighboring pixel structures by field oxide regions and by overlaying insulating material, the insulating material being a translucent or transparent insulating layer.

19. The CMOS image sensor structure of claim 18, wherein the translucent or transparent insulating material is a material selected from the group consisting essentially of SiO_2 , BPSG, PSG, BSG, or SOG.

20. An integrated circuit comprising: a semiconductor substrate having a pixel array region and a peripheral circuit region, the semiconductor substrate comprising:

a p-type substrate underlying a pixel array region and a peripheral region, the p-type substrate having a p-type substrate region and a p-type epitaxial region;

a deep n-type region (N-Tub region) having an n-type peripheral sidewall (N+ guard ring) within the p-type substrate, such that at least in the pixel array region, the N-Tub region is sandwiched between the p-type substrate region and a p-type epitaxial region and an upper p-type polysilicon region, the N-Tub region extending under the pixel array region and below field oxide regions which surround the pixel array region, the pixel array region enclosed by a peripheral p-well sidewall (p-type ground ring), the p-type ground ring extending below the field oxide regions and within the p-type polysilicon region and provides an electrical connection to the p-type epitaxial region; and

p-type conductive implant regions that connect the p-type epitaxial region to the p-type substrate through the N-Tub region.

21. The integrated circuit of claim 20, wherein the N+ guard ring is a contiguous structure that surrounds the pixel array region and extends downwardly to the N-Tub region.

22. The integrated circuit of claim 20, wherein the N+ guard ring isolates the p-type epitaxial region and an upper p-type polysilicon region from the p-type substrate and provides an electrical connection thereto.

23. The integrated circuit of claim 20, wherein the p-type ground ring is either a contiguous or non-contiguous structure that connects the p-type epitaxial to a given potential.

24. A processing system comprising: (i) a processor; and (ii) an imaging device coupled to the processor, the imaging device containing an image sensor which comprises:

a p-type substrate underlying a pixel array region and a peripheral region, the p-type substrate having a p-type substrate region and a p-type epitaxial region;

an n-type region (N-Tub region) having an n-type peripheral sidewall (N+ guard ring) within the p-type epitaxial region, the N-Tub region extending under the pixel array region and below field oxide regions which surround the pixel array region, the pixel array region enclosed by a peripheral p-well sidewall (p-type ground ring), the p-type ground ring extending below the field oxide regions and within and providing an electrical connection to the p-type epitaxial region; and

p-type conductive implant regions that connect the p-type epitaxial region to the p-type substrate through the N-Tub region at the red pixel locations.

25. The processing system of claim 24 further comprising a second p-type conductive implant region separating the N-Tub region from the red pixel locations.

26. The processing system of claim 24, wherein the N+ guard ring is a contiguous structure that surrounds the pixel array region and extends downwardly to the N-Tub region.

27. The processing system of claim 24, wherein the N+ guard ring isolates the p-type epitaxial region from the p-type substrate and provides an electrical connection to the N-Tub region.

28. The processing system of claim 24, wherein the p-type ground ring is either a contiguous or non-contiguous structure that connects the p-type epitaxial to a given potential.

29. A CMOS image sensor structure comprising:

an n-type substrate underlying a pixel array region and a peripheral region, the n-type substrate having an n-type substrate region with an n-type epitaxial region;

an n-type peripheral sidewall (N+ guard ring) arranged such that at least in the pixel array region, the n-type epitaxial region underlies a p-type conductive region, the n-type epitaxial region extending under the pixel array region and below surrounding field oxide regions, the pixel array region enclosed by a peripheral p-well sidewall (p-type ground ring), the p-type ground ring extending below the field oxide regions and within the p-type conductive region so as to provide an electrical connection to the p-type epitaxial region;

p-type conductivity extension regions that connect to the p-type conductive region of red pixel structures and extends into the n-type epitaxial region.

30. The CMOS image sensor structure of claim 29 further comprising a second p-type conductive implant region separating the n-type epitaxial region from the red pixel structures.

31. The CMOS image sensor structure of claim 29, wherein the N+ guard ring is a contiguous structure that surrounds the pixel array region and extends downwardly to the n-type epitaxial region.

32. The CMOS image sensor structure of claim 29, wherein the N+ guard ring isolates the p-type conductive region from the n-type epitaxial region and provides an electrical connection thereto.

33. The CMOS image sensor structure of claim 29, wherein the p-type ground ring is either a contiguous or non-contiguous structure that connects the p-type conductive region to a given potential.

34. A method for forming a CMOS image sensor comprising:

forming an n-type epitaxial region to overlay an n-type substrate;

forming a p-type conductive region on the n-type epitaxial region;

forming field oxide regions in the p-type conductive region;

forming a p-type ground ring inside the pixel array section to form a peripheral p-well wall thereabout that extends to contact the p-type conductive region;

forming an n-type sidewall (n-type guard ring) in the peripheral region that extends to the n-type epitaxial region and forms an n-type region isolation structure which separates the pixel array region from the peripheral region;

patterning an implant mask only over red pixel locations;

performing a p-type implant to create the p-type conductivity extension regions connecting to the p-type conductive region and extends into the n-type epitaxial region under the red pixel locations.

35. The method for forming a CMOS image sensor structure of claim 34, further comprising a second p-type conductive implant region separating the n-type epitaxial region from the red pixel structures.

36. The method for forming a CMOS image sensor structure of claim 34, wherein forming a n-type epitaxial layer is by growing epitaxial silicon.

37. The method for forming a CMOS image sensor structure of claim 34, wherein n-type epitaxial layer to a thickness of approximately 4 μm that is doped to a n-type conductivity using 4 ohms^{-cm} to a concentration of approximately 5E12 atoms cm⁻¹.

38. The method for forming a CMOS image sensor structure of claim 34, wherein forming field oxide regions comprises shallow trench isolation (STI) techniques.

39. The method for forming a CMOS image sensor structure of claim 34, wherein field oxide regions comprises an insulating material selected from the group consisting of silicon dioxide, silicon nitride, ON (oxide-nitride), NO (nitride-oxide), or ONO (oxide-nitride-oxide).

forming field oxide regions, such as by using shallow trench isolation (STI) are

40. The method for forming a CMOS image sensor structure of claim 34, wherein the p-type implant is performed such that the resulting p-type conductivity extension regions are at approximately the same depth, or at a deeper depth than n-type epitaxial region.

41. The method for forming a CMOS image sensor structure of claim 34, wherein the p-type implant is performed using a higher dose than an implant used during the n-type epitaxial implant such that the p-type implant will over compensate the n-type epitaxial region under the desired red pixel locations.

42. The method for forming a CMOS image sensor structure of claim **34**, wherein the p-type implant comprises using a boron dose greater than 5×10^{12} atoms cm^{-3} at an energy level of around 1.4 keV.

43. A CMOS image sensor structure comprising:
at least one red pixel structure residing within a p-type conductive region overlying an n-type epitaxial region;
and
a p-type conductive implant region connecting to the p-type conductive region and extending into the n-type epitaxial region.

44. The CMOS image sensor structure of claim **43** further comprising a second p-type conductive implant region separating the n-type epitaxial region from the at least one red pixel structure.

45. The CMOS image sensor structure of claim **43** further comprising a pinned photodiode having a photosensitive p-n junction region comprising a p-type surface layer and an n-type photodiode region.

46. The CMOS image sensor structure of claim **43** further comprising:
a floating diffusion region adjacent to an n-type conductive transfer gate;
each red pixel structure isolated from neighboring pixel structures by field oxide regions and by overlaying insulating material, the insulating material being a translucent or transparent insulating layer.

47. The CMOS image sensor structure of claim **46**, wherein the translucent or transparent insulating material is a material selected from the group consisting essentially of SiO_2 , BPSG, PSG, BSG, or SOG.

48. An integrated circuit comprising: a semiconductor substrate having a pixel array region and a peripheral circuit region, the semiconductor substrate comprising;

an n-type substrate underlying a pixel array region and a peripheral region, the n-type substrate having an n-type substrate region with an n-type epitaxial region;
an n-type peripheral sidewall (N+ guard ring) arranged such that at least in the pixel array region, the n-type epitaxial region underlies a p-type conductive region, the n-type epitaxial region extending under the pixel array region and below surrounding field oxide regions, the pixel array region enclosed by a peripheral p-well sidewall (p-type ground ring), the p-type ground ring extending below the field oxide regions and within the p-type conductive region so as to provide an electrical connection to the p-type epitaxial region;

p-type conductivity extension regions that connect to the p-type conductive region of red pixel structures and extends into the n-type epitaxial region.

49. The integrated circuit of claim **48** further comprising a second p-type conductive implant region separating the N-Tub region from the red pixel structures.

50. The integrated circuit of claim **48**, wherein the N+ guard ring is a contiguous structure that surrounds the pixel array region and extends downwardly to the n-type epitaxial region.

51. The integrated circuit of claim **48**, wherein the N+ guard ring isolates the p-type conductive region from the n-type epitaxial region and provides an electrical connection thereto.

52. The integrated circuit of claim **48**, wherein the p-type ground ring is either a contiguous or non-contiguous structure that connects the p-type conductive region to a given potential.

53. A processing system comprising: (i) a processor; and (ii) an imaging device coupled to the processor, the imaging device containing an image sensor which comprises:

an n-type substrate underlying a pixel array region and a peripheral region, the n-type substrate having an n-type substrate region with an n-type epitaxial region;

an n-type peripheral sidewall (N+ guard ring) arranged such that at least in the pixel array region, the n-type epitaxial region underlies a p-type conductive region, the n-type epitaxial region extending under the pixel array region and below surrounding field oxide regions, the pixel array region enclosed by a peripheral p-well sidewall (p-type ground ring), the p-type ground ring extending below the field oxide regions and within the p-type conductive region so as to provide an electrical connection to the p-type epitaxial region;

p-type conductivity extension regions that connect to the p-type conductive region of red pixel structures and extends into the n-type epitaxial region.

54. The processing system of claim **53** further comprising a second p-type conductive implant region separating the N-Tub region from the red pixel structures.

55. The processing system of claim **53**, wherein the N+ guard ring is a contiguous structure that surrounds the pixel array region and extends downwardly to the n-type epitaxial region.

56. The processing system of claim **53** wherein the N+ guard ring isolates the p-type conductive region from the n-type epitaxial region and provides an electrical connection thereto.

57. The processing system of claim **53** wherein the p-type ground ring is either a contiguous or non-contiguous structure that connects the p-type conductive region to a given potential.

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